M04a

Velocity and Magnetic Field Stratification Above a Forming Sunspot Derived from SUNRISE III/ SCIP Observations

〇Yuxiang Song[1, 2] Yukio Katsukawa[1, 2] Yusuke Kawabata[1] Masahito Kubo[1] Takayoshi Oba[3] Takuma Matsumoto[4] Ryohtaroh T Ishikawa[5] Yoshihiro Naito[1, 6] Carlos Quintero Noda[7] (1.National Astronomical Observatory of Japan 2.University of Tokyo 3.Kanazawa University 4.Nagoya University 5.National Institute for Fusion Science 6.The Graduate University for Advanced Studies (SOKENDAI) 7.Instituto de Astrofísica de Canarias)

The formation mechanism of sunspot penumbrae remains unsettled, and how the Evershed flow (EF) in the photosphere and inverse Evershed flow (IEF) in the chromosphere develop during the formation phase is still poorly constrained. In this work, we investigate the penumbra formation mechanism, with emphasis on mass flow and the evolution of magnetic topology. Thanks to SUNRISE III/SCIP, which provides high-resolution spectropolarimetric data with wide wavelength coverage, we are able to simultaneously analyze different atmospheric layers and investigate their temporal evolution. We analyze an evolving active region observed on 15 July 2024 from 10:05 to 13:51 UT, using Fe I 8468 Å (photosphere) and Ca II 8542 Å (chromosphere). In photospheric continuum maps, we identify a forming sunspot in the vicinity of mature sunspots. Dopplergrams from Fe I 8468 Å show persistent redshifted patches within the forming spot that are not fully consistent with typical EF signatures. Chromospheric Ca II 8542 Å line center images exhibit filamentary structures linking the forming spot to other sunspots. Spectra extracted along these filaments reveal supersonic redshifts concentrated near the ends of the filamentary structures above the forming sunspot. The redshift amplitude increases during the formation process, and the velocity enhancement appears to precede the growth of the spot area. This suggests that intensified downflows may be an early signature of sunspot formation and the resulting development of penumbrae. To put these findings, we will extend the photospheric velocity analysis to other lines, including the K I lines, and compare them with chromospheric velocities from Ca II 8542 Å to verify that the enhanced redshift is indeed a signature of sunspot and penumbra formation. We will also examine the temporal evolution of magnetic fields at multiple heights to connect the observed flow signatures to changes in magnetic structures.